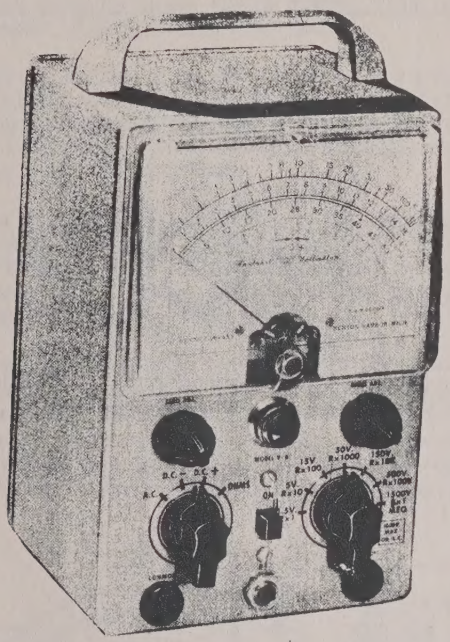
CONSTRUCTION MANUAL NO LONGER AVAILABLE

HEATHKIT VTVM • • • • MODEL V-6



SPECIFICATIONS

Power Requirements:	105-125V 50/60 Cycle AC, 10 Watts.
Cabinet Size:	7 3/8" high x 4 11/16" wide x 4 1/8" deep.
Kit Shipping Weight:	7 pounds
Meter:	$4\frac{1}{2}$" Streamlined case with 200 microampere movement.
Multipliers:	Precision type.
Tubes:	1 - 12AU7 Twin triode meter bridge. 1 - 6H6 Twin diode AC rectifier.
Power Supply:	Power transformer and selenium rectifier.
Battery	$1\frac{1}{2}$ Volt flashlight cell
D. C. Voltmeter: 7 Ranges:	0-1.5, 5, 15, 50, 150, 500, 1500 volts full scale. With accessory probe to 30,000 Volts.
Input Resistance:	11 Megohms (1 megohm in probe) on all ranges. 1,100 megohms with accessory probe.
Sensitivity:	7,333,333 ohms per volt on 1.5 Volt range.
Circuit:	Balanced bridge (push-pull) using twin triode.
Electronic AC Voltmeter: 7 Ranges:	0-1.5, 5, 15, 50, 150, 500, 1,500, (1000V Max.) Scales reading R.M.S. (.707 of positive peak).
Circuit:	Diode with adjustable compensation.
Electronic Ohmmeter: 7 Ranges:	Scale with 10 ohms center x1, x10, x100, x1000, x10K, x100K, x1 Meg. Measures .1 ohm to 1,000 megohms with internal battery.

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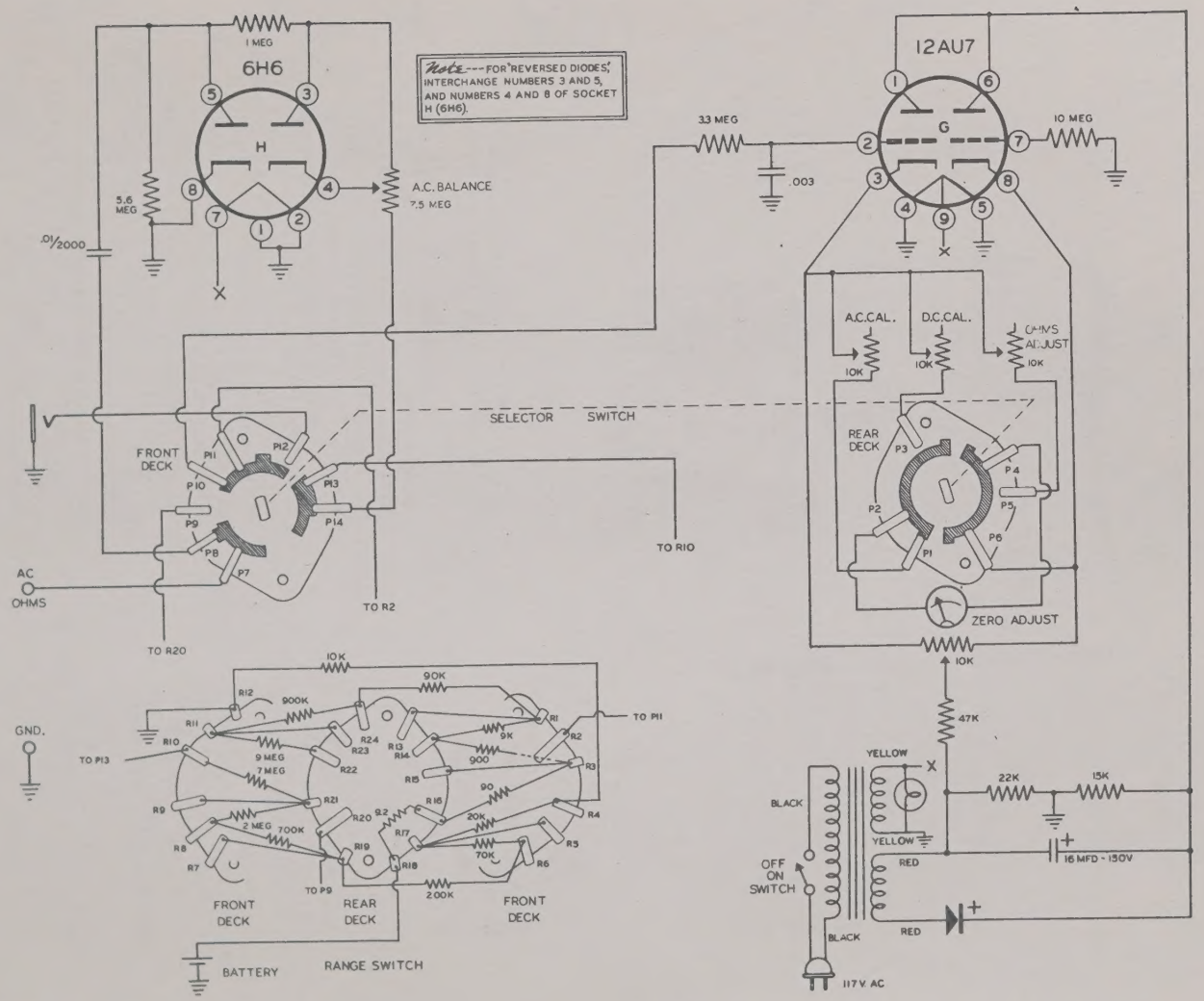

1 MEG
6H6
Note --- FOR REVERSED DIODES, INTERCHANGE NUMBERS 3 AND 5, AND NUMBERS 4 AND 8 OF SOCKET H (6H6).
A.C. BALANCE
7.5 MEG
5.6 MEG
.01/2000
12AU7
33 MEG
.003
10 MEG
A.C.CAL.
D.C.CAL.
OHMS ADJUST
10K
SELECTOR SWITCH
FRONT DECK
REAR DECK
TO R10
TO R2
AC OHMS
TO R20
ZERO ADJUST
47K
GND.
TO P13
TO P11
90K
900K
9K
900
9 MEG
7 MEG
2 MEG
700K
20K
70K
200K
TO P9
FRONT DECK
REAR DECK
FRONT DECK
BATTERY
RANGE SWITCH
YELLOW
22K
15K
BLACK
YELLOW
RED
16 MFD - 150V
OFF ON SWITCH
BLACK
RED
117 V AC

TEST AND CALIBRATION

Check over the wiring carefully. We suggest tracing over each wire on the pictorial with a colored pencil as it is checked on the instrument. Check each solder connection. Install the tubes.

Plug the instrument into a 117 Volt 50/60 Cycle AC ONLY outlet. This instrument will not operate, and serious damage will result, if plugged into a DC outlet.

Turn the switch on and allow a minute for warm up. Set the selector switch to DC+. Check operation of zero adjust control. Turning this control should move the meter pointer to about half or $\frac{3}{4}$ scale and to zero. Set pointer to zero and check if it remains on zero when switched to DC-. If there is appreciable zero shift (more than one or 2 divisions on the scale) the tubes must be aged. First complete the initial test, however.

Turn the instrument off and make sure the mechanical zero of the meter is correct. If not, adjust as follows: Place the instrument in normal operating position. (This usually is with the rubber feet on a level surface.) Turn the black plastic screw on the meter face with a screwdriver, while gently tapping the meter face with one finger, until the pointer coincides with the zero line on the left side of the scale. Turn the instrument on again.

Insert the common and DC test leads. Set the selector switch to DC+ and the range switch to 1.5V. Connect the test leads to the calibrated flashlight cell, and adjust the DC calibrate control (See Figure 18) so the meter pointer falls directly over the very small red dot on the meter face. (See Figure 19). Approach the red dot going up scale i.e., turn the calibrate control and watch the meter read 1.4V and 1.5V and then the red dot. As soon as the red dot is reached, stop turning the calibrate control. Remember the range switch must be set on 1.5V.

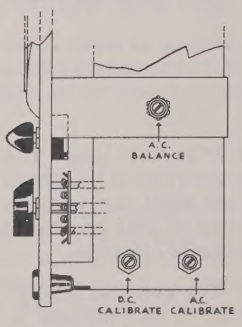


Fig. 18

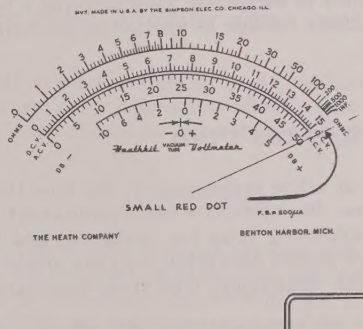


Fig. 19

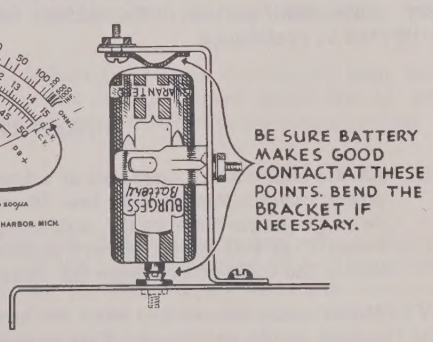


Fig. 20

Turn instrument OFF and install the battery in the battery bracket as shown in Figure 20. Turn instrument ON and let it warm up. Set selector switch to ohms. Pointer should swing to about full scale. Turn ohms adjust to give full scale reading (Infinite). Insert AC ohms test lead. Touch this lead to common lead and observe pointer dropping to zero indicating short circuit (no resistance).

Temporarily remove AC-ohms test lead. Set range switch to 1.5V and selector to AC. Adjust AC balance control so no movement is noticed in the pointer when switching from AC through DC- to DC+. Now set range switch to 150V and the selector switch to AC. Re-insert AC ohms lead. Connect AC ohms and common lead to the 117V AC line (NOTE: 117 Volt line is dangerous—proceed with due care) and adjust AC calibrate control so pointer indicates the line voltage.

It is recommended that the tubes be aged before final calibration. This is accomplished by keeping the instrument turned on for a period of at least 48 hours. Final calibration should be done in the same way as initial calibration. Careful calibration will result in a more accurate instrument. If a standard AC meter is available, it is desirable to use such an instrument, preferably at a voltage near full scale indication on the VTVM, as for instance 140 Volts or 40 Volts (on tne 150V or 50V range respectively).

After final calibration, place the instrument in the cabinet, and install two sheet metal screws through the back and into the chassis. The instrument is now ready for use.

CIRCUIT DESCRIPTION

The meter is in the cathode circuits of a twin triode. The zero adjust control sets up a balance between the two sections of the triode such that with zero input voltage applied to the first grid, the voltage drop across each portion of the adjust control (from adjust arm to one side, and adjust arm to the other side) is the same. This being true, the meter reads zero. With a voltage applied to the first grid, the balance in the cathode circuits is upset and the meter indicates. The relationship between the test voltage applied to the first grid and the meter indicating current is linear, and therefore the meter is calibrated with a linear scale. The advantage of having the meter in a vacuum tube circuit of this kind is that voltages to be measured are not applied directly to the meter but rather to the tube. Because the tube is limited to the amount of current it can draw, the meter movement is protected.

Calibration of the instrument is simple and is accomplished by adjustment of the AC and DC calibrate controls. These controls are in series with the meter and are adjusted to produce full scale reading with the proper test voltage applied to the instrument.

The maximum test voltage which is applied to the tube is about 3 volts. Higher test voltages are reduced by a voltage divider which has a total resistance of 10 megohms. An additional resistance of 1 megohm is located in the DC test prod thereby permitting measurements to be made in circuits carrying RF with a minimum disturbance of such circuits.

For AC voltages in the Audio Frequency range, a shunt fed diode is used to provide a DC voltage proportional to the peak of the applied AC voltage. This DC voltage is applied through the voltage divider to the tube, causing the meter to indicate. The AC calibrate control is used so as to obtain the proper meter deflection for the applied AC voltage. Vacuum tubes develop a contact potential voltage between tube elements. Such contact potential developed in the diode would cause a slight voltage to be present at all times. This voltage is cancelled out by bucking it with a portion of the contact potential of a second diode. The amount of bucking voltage is controlled by the AC balance control. This eliminates zero shift when switching from DC to AC.

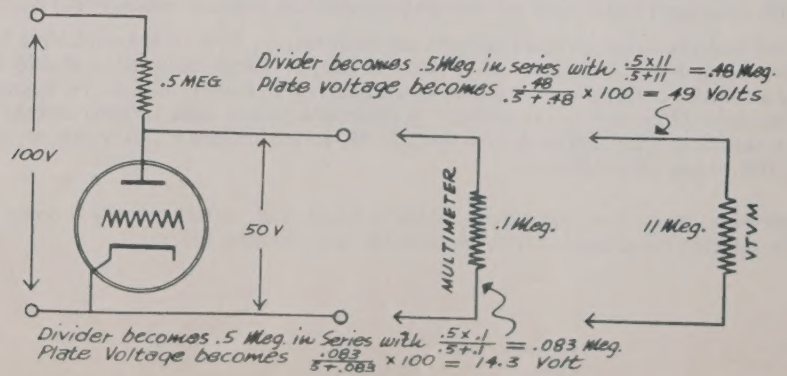
For resistance measurements, a $1\frac{1}{2}$ Volt battery is connected through a string of multipliers of 1% tolerance and the external resistance to be tested, thus forming a voltage divider across the battery. A resultant portion of the battery voltage is applied to the twin triode. The meter scale is calibrated in resistance.

USING THE VTVM

NOTE: As the heaters are operated at a low temperature, the tube life is extremely long. The power consumption is very low. We therefore recommend that this instrument be turned on at the same time as the soldering iron for instance, and left on until the work is done. This will result in very stable operation, and the slight amount of heat generated inside the cabinet will keep the instrument free from moisture in humid climates.

The VTVM has many advantages over the non-electronic volt-ohmmeters. The greatest advantage is the high input resistance. This enables much more accurate readings to be obtained in high impedance circuits, such as resistance coupled amplifiers, oscillator grid circuits and AVC networks.

To illustrate this, let us assume a resistance coupled audio amplifier with a .5 megohm plate load resistor, operating with a 100 Volt plate supply. Let us also assume that the plate voltage is 50 Volts and that, therefore, the tube acts as a .5 megohm resistor. Measuring the plate voltage with a conventional 1.000 ohm per volt instrument on the 100 Volt scale, the meter can be considered a 100,000 ohm (.1 megohm) resistor in parallel with the tube. The voltage on the plate is then about 14 Volts and is shown as such by the meter. This is due to the shunt resistance of the low resistance meter. Using the VTVM on any scale setting, the full 11 megohms is placed in parallel with the tube. The voltage on the plate is then about 49 Volts or 2% lower than the normal operating voltage. Thus accurate reading can only be obtained with the high resistance provided by a VTVM.


.5 MEG
Divider becomes .5 Meg. in series with $\frac{.5 \times 11}{.5+11} = .48$ Meg.
Plate voltage becomes $\frac{.48}{.5+.48} \times 100 = 49$ Volts
100V
50V
MULTIMETER
.1 Meg.
11 Meg.
VTVM
Divider becomes .5 Meg. in series with $\frac{.5 \times .1}{.5+.1} = .083$ Meg.
Plate Voltage becomes $\frac{.083}{.5+.083} \times 100 = 14.3$ Volt

An understanding of the characteristics of your instrument will result in greater satisfaction through proper use.

DC VOLTAGE

To measure DC voltage with the VTVM, connect the common (black) lead to the common or "cold" side of the voltage to be measured. Set the selector switch to DC+ or DC- as required and set the range switch to a range greater than the voltage to be measured, if known. If unknown, set to 1,500 Volts. With black test prod, touch other or "hot" side of the voltage to be measured. If pointer moves less than one-third of full scale, switch to the next lower range.

AC VOLTAGE

IMPORTANT WARNING: THE 1500V MARKING ON THE LAST SCALE APPLIES TO DC VOLTAGES ONLY. VOLTAGES IN EXCESS OF 1000V AC MUST NOT BE APPLIED TO THE VTVM. THIS WARNING IS CLEARLY SHOWN ON THE PANEL AND MUST BE OBSERVED. THE HEATH COMPANY ASSUMES ABSOLUTELY NO RESPONSIBILITY NOR OBLIGATION FOR ANY DAMAGES TO THE INSTRUMENT CAUSED BY APPLYING AC VOLTAGES IN EXCESS OF 1000 VOLTS TO THE VTVM.

To measure AC voltage with the VTVM, connect the common (black) lead to the common or "cold" side of the voltage to be measured. Set the selector switch to AC, and set the range switch to a range greater than the voltage to be measured, if known. If unknown, set to 1,500 Volts. With red test prod, touch other or "hot" side of the voltage to be measured. DO NOT MEASURE AC VOLTAGES IN EXCESS OF 1000V. If pointer moves less than one-third of full scale, switch to the next lower range.

The Heathkit is an extremely sensitive electronic AC voltmeter and as the human body picks up AC when near any AC wires, the meter will indicate this pickup. Never touch the AC prod when on the lower ranges. Zero should be set with the AC prod shorted to the common clip.

RESISTANCE

To measure resistance with the VTVM, connect the common (black) lead to one side of the resistor to be measured. Set the selector to ohms, and set the range switch to such a range that the reading will fall as near to mid-scale as possible. Set the ohms adjust control so the meter indicates exactly full scale (INF. on ohms scale). Then touch the red test prod to the other side of the resistor to be measured. Read resistance on ohms scale and multiply by the proper factor as shown by the range switch setting.

NOTE: Although batteries are used to measure resistance, the indication is obtained through the electronic meter circuit, and therefore, the instrument must be connected to the AC power line and tuned on.

CAUTION: Never leave the instrument on ohms, as it greatly shortens the life of the ohmmeter battery.

USING THE VTVM DECIBEL SCALE

Because the human ear does not respond to volume of sound in proportion to signal strength, a unit of measure called the "bel" was adopted. The "bel" is more nearly equivalent to human ratios. Normally the reading is given in 1/10 of a "bel" or decibel."

Various signal levels are adopted by various manufacturers as standard or "O" decibels.

The Heathkit VTVM DB scale uses a standard of 1 milliwatts into a 600 ohm line as "O" decibels. This corresponds to .774 VAC on the 0-1.5V scale. From this figure, the various AC ranges of the VTVM may be converted to db by the following chart:

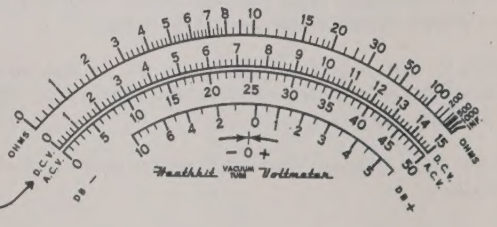
AC VOLTS SCALE	DECIBEL SCALE
0-1.5V	Read db directly
0-5V	Add 10 db to the reading
0-15V	Add 20 db to the reading
0-50V	Add 30 db to the reading
0-150V	Add 40 db to the reading
0-500V	Add 50 db to the reading
0-1500V (1000V AC max.)	Add 60 db to the reading

As the decibel is a power ratio or voltage ratio, it may be used as such without specifying the reference level. Thus for instance, a fidelity curve may be run on an amplifier by feeding in a signal of variable frequency but constant amplitude. At a reference frequency of say 400 cycles, adjust input to give a convenient indication (O db for instance) on the VTVM connected to the output. As the input frequency is varied, the output level variation may be noted directly in db above and below the specified reference level.
NOTE: When measuring complex AC wave shapes, such as ripple, hum, distorted and square waves, the indication is 70% of the positive peak.

READING THE METER SCALE

The voltage markings on the range switch refer to the FULL SCALE reading. The scale is marked 0-15 and 0-50 for voltage. On the 1.5 Volt range, read the 0-15 scale and move the decimal one place to the left. Thus, for example, a reading of 8 would represent a voltage of .8 volts. On the 5V range, read the 0-50 scale and move the decimal one place to the left (i.e., drop the zero). A reading of 40V would represent a voltage of 4 volts. On the 15V range read the 0-15 scale directly (example, a reading of 4V represents a voltage of 4V). On the 50V range read the 0-50V directly. On the 150V range, read the 0-15 scale and add one zero (example, a reading of 12 represents a voltage of 120V). On the 500V range read the 0-50 scale and add one zero (example, a reading of 40 represents a voltage of 400V). On the 1500V range read the 0-15 scale and add two zeros (example, a reading of 8 represents a voltage of 800V).

NOTE: This marking does not mean that the upper scale indicates ACV and the lower scale DCV. Rather, it means that either scale will read ACV or DCV, depending on the setting of the selector switch.



The resistance marking or ohms scale refers to the lowest resistance range (Rx1). For the other ranges, add the proper number of zeros (add two zeros for Rx100, add four zeros for Rx10K, add six zeros for Rx1 Meg). On the Rx1 Meg range, the scale can also be considered to read directly in megohms.

ACCURACY

The accuracy of the meter movement is within 2% of full scale, which means that, for instance on the 1000 Volt range the accuracy of the movement will be within 20 Volts at any point on the scale. On DC, the accuracy of the multiplier (1%) may be additive, resulting in an accuracy of within 3% of full scale.

On AC, the accuracy of the rectifier circuit contributes variations which result in accuracy of within 5% of full scale.

The accuracy on the ohms ranges depends on the meter accuracy, the ohms multiplier accuracy (including the internal resistance of the batteries), and the stability of the battery voltage. On the Rx1 scale, the internal resistance of the batteries and the battery voltage both vary as result of the current drawn by the resistance under test. For greatest accuracy, tests on low resistance values should be made as quickly as possible. On the higher ohms ranges, the accuracy depends practically on the multipliers, which are 1%, and the meter movement accuracy. Because of the non-linear ohms scale, the resulting accuracy is not readily expressed in a percentage figure, but the greatest accuracy is obtained at mid-scale readings.

NOTE: When comparing this instrument with another instrument, consider that the accuracy of the other instrument may deviate in the opposite direction. Therefore, when comparing two instrument of 5% accuracy, the difference might be a total of 10%. Critical comparisons should only be made against certified laboratory standards.

IN CASE OF DIFFICULTY

1. Recheck the wiring. Most cases of trouble result from wrong or reversed connections. Often having a friend check the wiring will reveal a mistake consistently overlooked.

2. Check the tubes.

   The possibility exists that a perfectly balanced tube will not permit Zero center adjustment on either DC+ or DC-. Then add 1000 ohms or more in series with either 12AU7 cathodes and the Zero adjust control.

3. If the pointer swings full scale to the right and stays there with switch set to DC+, check for an open circuit or high resistance connection somewhere between the grid pin #2 of the 12AU7 and ground. This might be due to a wrong connection to the selector switches, a poor connection, or possibly an open resistor.

   If the instrument does not operate on any function, a check of the power supply, and the 12AU7 and its associated meter circuit is suggested.

   If the instrument only fails to function on AC measurements, then a check of the 6H6 and its associated circuits should be made.

   If the instrument only fails to function on ohms, the difficulty will probably be due to the battery (make certain the battery is making good contact in the bracket) or the ohms multipliers.

   Proper operation on DC should first be secured before an attempt is made to use the instrument on AC or ohms.

4. Check the operating voltages. The following voltages are measured to chassis: Pin #1 or #6 on 12AU7 tube or + lug on rectifier 35-70 Volts positive. Negative lug on rectifier 70-110V negative. Pin 7 of 6H6 and pin 9 of 12AU7, 5-6V AC.

5. Check continuity through the DC test cable. Make certain that the shielding is not shorted to center conductor.

V-6 VACUUM TUBE VOLTMETER PARTS LIST.

Part No.	Parts Per Kit	Description
Resistors		
2-48	1	9.2 Ohm Precision
2-24	1	90 Ohm Precision
2-29	1	900 Ohm Precision
2-35	1	9K Ohm Precision
2-50	1	10K Ohm Precision
2-38	1	20K Ohm Precision
2-9	1	70K Ohm Precision
2-41	1	90K Ohm Precision
2-54	1	200K Ohm Precision
2-13	1	700K Ohm Precision
2-51	1	900K Ohm Precision
2-55	1	2 Megohm Precision
2-16	1	7 Megohm Precision
2-22A	1	9 Megohm Precision
1-21	1	15K
1-22	1	22K
1-25	1	47K
1-35	2	1 Megohm
1-38	1	3.3 Megohm
1-42A	1	5.6 Megohm
1-40	1	10 Megohm
Condensers		
20-8	1	.003 MFD
23-5	1	.01 MFD 2000 Volt
25-5	1	16 MFD 150 Volt
Controls		
10-9	2	10K Ohms (AC & DC Calibrate)
10-8	2	10K Ohms (Ohms & Zero Adjust)
10-28	1	7.5 Megohm (AC balance)
Switches		
63-18	1	Selector
63-42	1	Range
60-1	1	SPST Slide
Tubes—Lamp		
411-33	1	6H6 Tube
411-25	1	12AU7 Tube
412-1	1	#47 Pilot Lamp
Wire—Plugs—Prods		
344-1	1	Roll Hookup Wire
346-1	1	Length Spaghetti
341-2	1	Length Red Test Lead 3 Ft.
341-1	1	Length Black Test Lead 3 Ft.
343-1	1	Length Shielded Test Lead 3 Ft.
89-1	1	Line Cord
438-M8	2	Sleeve and Plug Assemblies
70-3	1	Red Banana Plug Insulator Sleeve
70-2	1	Black Banana Plug Insul. Sleeve
438-3	1	Phone Plug
439-1	1	Red Test Prod
439-2	1	Black Test Prod

Part No.	Parts Per Kit	Description
Sockets—Terminal Strips—Jacks—Fiber Washers		
434-16	1	Miniature Socket (9 pin)
434-25	1	Octal Socket
434-22	1	Pilot Light Socket
252-12	1	Pilot Light Nut
455-1	1	Pilot Light Bushing
413-1	1	Pilot Light Jewel
431-1	1	1 Lug Terminal Strip
431-3	1	3 Lug Terminal Strip
436-3	1	Banana Jack (Red)
436-2	1	Banana Jack (Black)
437-1	2	Banana Jack Inserts
436-1	1	Phone Jack
253-2	1	$\frac{1}{4}$ Fiber Shoulder Washer #6
253-1	1	9/64 Plain Fiber Washer
Hardware		
250-4	2	4-40 x $\frac{1}{4}$ Screws
252-2	2	4-40 Nuts
250-2	2	3-48 x $\frac{1}{4}$ Screws
252-1	2	3-48 Nuts
250-9	9	6-32 x 3/8 Screws
250-26	1	6-32 x $\frac{1}{2}$ Binder Head Screw
250-8	2	#6 x 3/8 Sheet Metal Screws
250-19	2	10-24 x 3/8 Handle Screws
250-22	2	Pointer Knob Set Screws
250-30	2	Banana Plug Screws
252-3	10	6-32 Nuts
252-7	8	Control Nuts
254-1	13	#6 Lockwashers
254-4	8	Control Lockwashers
253-10	5	Control Nickel Washers
252-9	2	Speednuts for Jacks
259-1	2	Solder Lugs
73-1	3	3/8 Grommets
261-1	4	Rubber Feet
208-2	1	Battery Spring Clip
260-4	1	Battery Base Clip
204-M36	1	Battery Mtg. Z Angle Bracket
204-M33	1	L Chassis Bracket
260-1	1	Alligator Clip
Miscellaneous		
462-4	2	Acorn Knobs
462-M11	2	Pointer Knobs
407-16	1	200 Microamp Meter.
418-1	1	Flashlight Cell (Calibrated)
57-1	1	Selenium Rectifier
54-2	1	Power Transformer
200-M32	1	Chassis
211-1	1	Handle
203-3F1	1	Front Panel
90-17	1	Cabinet and Rear Cover
595-40	1	V-6 Manual

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